

AD-279 335

USADAC TECHNICAL LIBRARY



5 0712 01015250 1

SPRINGFIELD ARMORY

SPRINGFIELD, MASSACHUSETTS

RESEARCH AND DEVELOPMENT

Report: SA-TR20-2809

Date: 10 October 1960

Report Title: Feasibility Study of a Variable Firing Rate Function
Generator for Analog Computers

Author

D. Gelfond
D. GELFOND
Electronic Engr (Instr)

Approved

H. F. Hawthorne
H. F. HAWTHORNE
Chief, Res and Dev Div

TECHNICAL
LIBRARY

MASTER FILE
DO NOT REMOVE



Wing-Tonfas Vaughn
TECHNICAL DIV LAB

ASTIA AVAILABILITY NOTICE. Qualified requesters may obtain copies of this report from ASTIA.

Report: SA-TR20-2809

Date: 10 October 1960

Report Title: Feasibility Study of a Variable Firing Rate Function
Generator for Analog Computers

Author D. Gelfond
D. GELFOND
Electronic Engr (Instr)

Approved H. F. Hawthorne
H. F. HAWTHORNE
Chief, Res and Dev Div

Project Title: Basic Studies in Ordnance Engineering (Sub-Audio Oscillator)

OMS Code: 5010.11.82000.00.01

DA Project: 572-01-004

Preparing Agency: Springfield Armory
Springfield, Mass.

To the extent known, this report does not contain any patented material, trade secrets, copyrighted and/or copyrightable material, trade marks or trade names.

NONLIMITATION ON REPRODUCTION AND DISTRIBUTION. This is a nonlimited distribution report. Initial distribution of the report has been made in accordance with the attached distribution list. Reproduction and/or distribution by any installation or agency is authorized.

DISPOSITION: Destroy - do not return.

ABSTRACT

A feasibility study is presented of a function generator to simulate the firing pulses of an externally powered machine gun during the analog computer analysis of the recoil motion of the gun. The function generator has a rate that can be varied to simulate the change in firing rate that occurs during the firing acceleration interval of the operational cycle of the weapon. A heterodyne system with a voltage-controlled oscillator was one of the systems studied and found to be impractical. The second system was an electronic time interval generator. This system was found to be the most practical. A variable firing rate function generator can be developed to reproduce with reasonable accuracy the performance of an externally driven weapon during the acceleration period.

REPORT
SA-TR20-2809

CONTENTS

	<u>Page</u>
Abstract	1
Subject	3
Object	3
Conclusion	3
Introduction	4
Results	4
Conclusions	6
Appendix A - Solution of Control Equation	8
Appendix B - Comparison of Time Intervals	9
Appendix C - Typical Performance Curves	10
Appendix D - Drawing of a Variable Rate Pulse Generator with Coincident Starting	12
Appendix E - Distribution	13

SUBJECT

Improvement in Analog Simulation of Externally Driven Weapons

OBJECT

Feasibility study for a swept-frequency sub-audio oscillator.

CONCLUSION

A variable firing rate function generator can be developed to reproduce with reasonable accuracy the performance of an externally driven weapon during the acceleration period.

1. SUBJECT

Improvement in Analog Simulation of Externally Driven Weapons

2. INTRODUCTION

In order that the analog computer analysis of the recoil motion of an externally driven weapon be correct, it is necessary to simulate the change in firing rate which occurs during the weapon acceleration interval. It is recognized that this could be done in several ways. The firing impulse could be introduced manually by the computer operator or it could be introduced by some mechanical method. Neither of these methods seemed satisfactory from the standpoint of accuracy, flexibility, and repeatability.

The possibility of using a voltage-controlled oscillator for this purpose was considered. Initially, a heterodyne system was studied. One frequency was to be time-varied by a predetermined control signal shaped so that the variation between beat frequency cycles would simulate the change in firing rate. In essence, this is the condition of frequency modulation. Although this appears straightforward, several other aspects must be considered.

During the quiescent state a beat signal should not be evident, requiring that the oscillators be "locked" in phase. The condition of the controlled oscillator should always be the same when a control signal is applied to maintain the relationship between the start of motion and the time at which the first round is fired. Also, the generation of the control signal presents some additional problems. Finally the sub-audio oscillator output voltage would have to be shaped into a trigger pulse to drive the normal $F(t)$ impulse generator used in the computer. All this complexity makes the use of the heterodyne system for this express purpose impractical.

As a result of the critical review of the heterodyne system, a better understanding of the requirements to be imposed on this function generator was reached. This led to the conclusion that the use of an electronic time interval generator would be advantageous. Of the several types available, the phanastron was chosen. It can provide a very large ratio of time intervals; the generated time interval is a linear function of the applied control signal.

3. RESULTS

An analysis of the recycling action will not be given here since this can be found in most of the current texts for electronic waveform generators¹. During the generation of an interval, the phanastron behaves as an integrator; this portion of its operation will be analyzed here.

1. MIT Radiation Series, Vol. 19, "Waveforms"

The general expression for the output voltage is:

$$(1) \quad v = V_0 - 1/R_1C_1 \int_{t_1}^{t_2} E_m f(t) dt$$

$E_m f(t)$ = control voltage

R_1C_1 = integrator time constant

V_0 = initial value of output voltage

v = instantaneous value of output voltage

As it is used here, the phanastron will recycle several times before the control voltage reaches a steady state value. Therefore, equation (1) should be rewritten to include a term representing the control voltage at the instant a new cycle is started.

$$(2) \quad v = V_0 - 1/R_1C_1 \int_{t_1}^{t_2} e_i dt - 1/R_1C_1 \int_{t_1}^{t_2} (E_m - e_i)f(t) dt$$

where $e_i = E_m f(t_1)$

To prove the validity of the analysis, known parameters are substituted in equation (2). The cycle times are calculated and compared with measured values.

$$\text{let } f(t) = 1 - e^{-t/R_2C_2}$$

$$(3) \quad v = V_0 - e/R_1C_1 \int_{t_1}^{t_2} dt - (E - e)/R_1C_1 \int_{t_1}^{t_2} (1 - e^{-t/R_2C_2}) dt$$

Solving (3) yields

$$(4) \quad V_0 R_1 C_1 / (E - e) \cdot (R_2 C_2) - E(t_2 - t_1) / (E - e)(R_2 C_2) - e^{-t_2/R_2 C_2} + e^{-t_1/R_2 C_2} = 0$$

The numerical solution is given in Appendix A. Comparison between the calculated and measured values gives an error not exceeding five per cent (Appendix B) for an individual cycle. Therefore, it is shown that the performance of the phanastron with a variable control voltage is readily predictable and that precision components are not required where moderate accuracy is acceptable. Appendix C shows pictorially the control and output signals.

The major disadvantage is the use of an analog control voltage to sweep the oscillator. This could be overcome by using an incremental control voltage that could be advanced during the recycling time of the phanastron. However, this aspect was not investigated.

REPORT
SA-TR20-2809

4. CONCLUSIONS

In summary then, it is feasible to construct a variable firing rate function generator for the analog computer, and though the original heterodyne approach was discarded the second approach is practical.

APPENDICES

REPORT
SA-TR20-2809

Appendix A - Solution of Control Equation (3)

Appendix B - Comparison of Time Intervals

Appendix C - Typical Performance Curves

Appendix D - Drawing SA-C43345

Appendix E - Distribution

SOLUTION OF CONTROL EQUATION (3)

$$(3) \quad v = V_o - e/R_1C_1 \int_{t_1}^{t_2} dt - (E-e)/R_1C_1 \int_{t_1}^{t_2} (1 - E^{-t/R_2C_2}) dt$$

$$v = V_o - (E/R_1C_1)(t_2-t_1) - \frac{(E-e)R_2C_2}{R_1C_1} (E^{-t_2/R_2C_2} - E^{-t_1/R_2C_2})$$

A cycle ends when $v = 0$, therefore

$$(4) \quad 0 = V_o R_1C_1/(E-e)(R_2C_2) - \frac{E(t_2-t_1)}{(E-e)(R_2C_2)} - E^{-t_2/R_2C_2} + E^{-t_1/R_2C_2}$$

Solving (4) for t_2 ,

$$\text{let } t_1 = 0$$

$$R_2C_2 = 15 \text{ seconds}$$

$$R_1C_1 = 1/3 R_2C_2$$

t_2

R_1C_1

$$V_o = 200 \text{ volts}$$

$$E = 170 \text{ volts}$$

$$e = E(1 - E^{-t_1/R_2C_2}) + 30$$

$$x = t_2/R_2C_2$$

$$(5) \quad 1.477 - 1.212x - e^{-x} = 0$$

$$x = .87$$

$$t_2 = 13.9 \text{ seconds}$$

This procedure is continued for consecutive values of t .

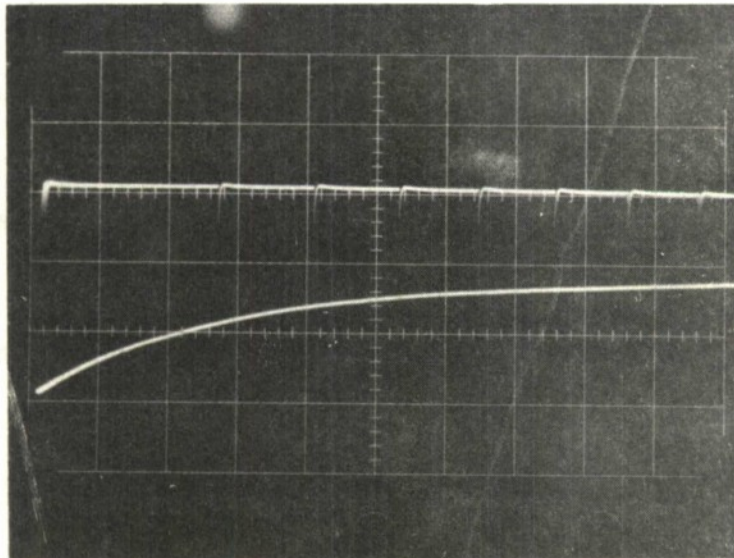
Appendix B

REPORT
SA-TR20-2809

COMPARISON OF TIME INTERVALS

	<u>Calculated</u>			<u>Measured</u>	
t2	13.9	Seconds		13.2	Seconds
t3	20.8	"		20.2	"
t4	27.0	"		26.4	"
t5	33.1	"		32.2	"
t6	39.1	"		38.8	"
t7	45.2	"		44.2	"
t8	51.2	"		49.6	"

TYPICAL PERFORMANCE CURVES



Upper trace: Generator output - 50v/div

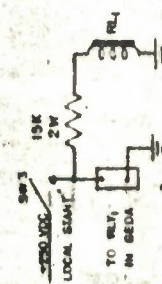
Lower trace: Control voltage - 100v/div

Time scale: 5 sec/div

Appendix D

REPORT
SA-TR20-2809

Drawing SA-C43345



1. ADJUST THIS VOLTAGE UNTIL IT IS EQUAL TO MEASURING VOLTAGE AT PIN 4 OF RESULT
2. ADJUST THIS VOLTAGE TO 20 VOLTS

ORDNANCE CORPS DEPT OF THE ARMY	SA-C-43345	REV 1
REVISIONS	REV 2	REV 3
REVISIONS	REV 4	REV 5
REVISIONS	REV 6	REV 7
REVISIONS	REV 8	REV 9
REVISIONS	REV 10	REV 11
REVISIONS	REV 12	REV 13
REVISIONS	REV 14	REV 15
REVISIONS	REV 16	REV 17
REVISIONS	REV 18	REV 19
REVISIONS	REV 20	REV 21
REVISIONS	REV 22	REV 23
REVISIONS	REV 24	REV 25
REVISIONS	REV 26	REV 27
REVISIONS	REV 28	REV 29
REVISIONS	REV 30	REV 31
REVISIONS	REV 32	REV 33
REVISIONS	REV 34	REV 35
REVISIONS	REV 36	REV 37
REVISIONS	REV 38	REV 39
REVISIONS	REV 40	REV 41
REVISIONS	REV 42	REV 43
REVISIONS	REV 44	REV 45
REVISIONS	REV 46	REV 47
REVISIONS	REV 48	REV 49
REVISIONS	REV 50	REV 51
REVISIONS	REV 52	REV 53
REVISIONS	REV 54	REV 55
REVISIONS	REV 56	REV 57
REVISIONS	REV 58	REV 59
REVISIONS	REV 60	REV 61
REVISIONS	REV 62	REV 63
REVISIONS	REV 64	REV 65
REVISIONS	REV 66	REV 67
REVISIONS	REV 68	REV 69
REVISIONS	REV 70	REV 71
REVISIONS	REV 72	REV 73
REVISIONS	REV 74	REV 75
REVISIONS	REV 76	REV 77
REVISIONS	REV 78	REV 79
REVISIONS	REV 80	REV 81
REVISIONS	REV 82	REV 83
REVISIONS	REV 84	REV 85
REVISIONS	REV 86	REV 87
REVISIONS	REV 88	REV 89
REVISIONS	REV 90	REV 91
REVISIONS	REV 92	REV 93
REVISIONS	REV 94	REV 95
REVISIONS	REV 96	REV 97
REVISIONS	REV 98	REV 99
REVISIONS	REV 100	REV 101
REVISIONS	REV 102	REV 103
REVISIONS	REV 104	REV 105
REVISIONS	REV 106	REV 107
REVISIONS	REV 108	REV 109
REVISIONS	REV 110	REV 111
REVISIONS	REV 112	REV 113
REVISIONS	REV 114	REV 115
REVISIONS	REV 116	REV 117
REVISIONS	REV 118	REV 119
REVISIONS	REV 120	REV 121
REVISIONS	REV 122	REV 123
REVISIONS	REV 124	REV 125
REVISIONS	REV 126	REV 127
REVISIONS	REV 128	REV 129
REVISIONS	REV 130	REV 131
REVISIONS	REV 132	REV 133
REVISIONS	REV 134	REV 135
REVISIONS	REV 136	REV 137
REVISIONS	REV 138	REV 139
REVISIONS	REV 140	REV 141
REVISIONS	REV 142	REV 143
REVISIONS	REV 144	REV 145
REVISIONS	REV 146	REV 147
REVISIONS	REV 148	REV 149
REVISIONS	REV 150	REV 151
REVISIONS	REV 152	REV 153
REVISIONS	REV 154	REV 155
REVISIONS	REV 156	REV 157
REVISIONS	REV 158	REV 159
REVISIONS	REV 160	REV 161
REVISIONS	REV 162	REV 163
REVISIONS	REV 164	REV 165
REVISIONS	REV 166	REV 167
REVISIONS	REV 168	REV 169
REVISIONS	REV 170	REV 171
REVISIONS	REV 172	REV 173
REVISIONS	REV 174	REV 175
REVISIONS	REV 176	REV 177
REVISIONS	REV 178	REV 179
REVISIONS	REV 180	REV 181
REVISIONS	REV 182	REV 183
REVISIONS	REV 184	REV 185
REVISIONS	REV 186	REV 187
REVISIONS	REV 188	REV 189
REVISIONS	REV 190	REV 191
REVISIONS	REV 192	REV 193
REVISIONS	REV 194	REV 195
REVISIONS	REV 196	REV 197
REVISIONS	REV 198	REV 199
REVISIONS	REV 200	REV 201
REVISIONS	REV 202	REV 203
REVISIONS	REV 204	REV 205
REVISIONS	REV 206	REV 207
REVISIONS	REV 208	REV 209
REVISIONS	REV 210	REV 211
REVISIONS	REV 212	REV 213
REVISIONS	REV 214	REV 215
REVISIONS	REV 216	REV 217
REVISIONS	REV 218	REV 219
REVISIONS	REV 220	REV 221
REVISIONS	REV 222	REV 223
REVISIONS	REV 224	REV 225
REVISIONS	REV 226	REV 227
REVISIONS	REV 228	REV 229
REVISIONS	REV 230	REV 231
REVISIONS	REV 232	REV 233
REVISIONS	REV 234	REV 235
REVISIONS	REV 236	REV 237
REVISIONS	REV 238	REV 239
REVISIONS	REV 240	REV 241
REVISIONS	REV 242	REV 243
REVISIONS	REV 244	REV 245
REVISIONS	REV 246	REV 247
REVISIONS	REV 248	REV 249
REVISIONS	REV 250	REV 251
REVISIONS	REV 252	REV 253
REVISIONS	REV 254	REV 255
REVISIONS	REV 256	REV 257
REVISIONS	REV 258	REV 259
REVISIONS	REV 260	REV 261
REVISIONS	REV 262	REV 263
REVISIONS	REV 264	REV 265
REVISIONS	REV 266	REV 267
REVISIONS	REV 268	REV 269
REVISIONS	REV 270	REV 271
REVISIONS	REV 272	REV 273
REVISIONS	REV 274	REV 275
REVISIONS	REV 276	REV 277
REVISIONS	REV 278	REV 279
REVISIONS	REV 280	REV 281
REVISIONS	REV 282	REV 283
REVISIONS	REV 284	REV 285
REVISIONS	REV 286	REV 287
REVISIONS	REV 288	REV 289
REVISIONS	REV 290	REV 291
REVISIONS	REV 292	REV 293
REVISIONS	REV 294	REV 295
REVISIONS	REV 296	REV 297
REVISIONS	REV 298	REV 299
REVISIONS	REV 300	REV 301
REVISIONS	REV 302	REV 303
REVISIONS	REV 304	REV 305
REVISIONS	REV 306	REV 307
REVISIONS	REV 308	REV 309
REVISIONS	REV 310	REV 311
REVISIONS	REV 312	REV 313
REVISIONS	REV 314	REV 315
REVISIONS	REV 316	REV 317
REVISIONS	REV 318	REV 319
REVISIONS	REV 320	REV 321
REVISIONS	REV 322	REV 323
REVISIONS	REV 324	REV 325
REVISIONS	REV 326	REV 327
REVISIONS	REV 328	REV 329
REVISIONS	REV 330	REV 331
REVISIONS	REV 332	REV 333
REVISIONS	REV 334	REV 335
REVISIONS	REV 336	REV 337
REVISIONS	REV 338	REV 339
REVISIONS	REV 340	REV 341
REVISIONS	REV 342	REV 343
REVISIONS	REV 344	REV 345
REVISIONS	REV 346	REV 347
REVISIONS	REV 348	REV 349
REVISIONS	REV 350	REV 351
REVISIONS	REV 352	REV 353
REVISIONS	REV 354	REV 355
REVISIONS	REV 356	REV 357
REVISIONS	REV 358	REV 359
REVISIONS	REV 360	REV 361
REVISIONS	REV 362	REV 363
REVISIONS	REV 364	REV 365
REVISIONS	REV 366	REV 367
REVISIONS	REV 368	REV 369
REVISIONS	REV 370	REV 371
REVISIONS	REV 372	REV 373
REVISIONS	REV 374	REV 375
REVISIONS	REV 376	REV 377
REVISIONS	REV 378	REV 379
REVISIONS	REV 380	REV 381
REVISIONS	REV 382	REV 383
REVISIONS	REV 384	REV 385
REVISIONS	REV 386	REV 387
REVISIONS	REV 388	REV 389
REVISIONS	REV 390	REV 391
REVISIONS	REV 392	REV 393
REVISIONS	REV 394	REV 395
REVISIONS	REV 396	REV 397
REVISIONS	REV 398	REV 399
REVISIONS	REV 400	REV 401
REVISIONS	REV 402	REV 403
REVISIONS	REV 404	REV 405
REVISIONS	REV 406	REV 407
REVISIONS	REV 408	REV 409
REVISIONS	REV 410	REV 411
REVISIONS	REV 412	REV 413
REVISIONS	REV 414	REV 415
REVISIONS	REV 416	REV 417
REVISIONS	REV 418	REV 419
REVISIONS	REV 420	REV 421
REVISIONS	REV 422	REV 423
REVISIONS	REV 424	REV 425
REVISIONS	REV 426	REV 427
REVISIONS	REV 428	REV 429
REVISIONS	REV 430	REV 431
REVISIONS	REV 432	REV 433
REVISIONS	REV 434	REV 435
REVISIONS	REV 436	REV 437
REVISIONS	REV 438	REV 439
REVISIONS	REV 440	REV 441
REVISIONS	REV 442	REV 443
REVISIONS	REV 444	REV 445
REVISIONS	REV 446	REV 447
REVISIONS	REV 448	REV 449
REVISIONS	REV 450	REV 451
REVISIONS	REV 452	REV 453
REVISIONS	REV 454	REV 455
REVISIONS	REV 456	REV 457
REVISIONS	REV 458	REV 459
REVISIONS	REV 460	REV 461
REVISIONS	REV 462	REV 463
REVISIONS	REV 464	REV 465
REVISIONS	REV 466	REV 467
REVISIONS	REV 468	REV 469
REVISIONS	REV 470	REV 471
REVISIONS	REV 472	REV 473
REVISIONS	REV 474	REV 475
REVISIONS	REV 476	REV 477
REVISIONS	REV 478	REV 479
REVISIONS	REV 480	REV 481
REVISIONS	REV 482	REV 483
REVISIONS	REV 484	REV 485
REVISIONS	REV 486	REV 487
REVISIONS	REV 488	REV 489
REVISIONS	REV 490	REV 491
REVISIONS	REV 492	REV 493
REVISIONS	REV 494	REV 495
REVISIONS	REV 496	REV 497
REVISIONS	REV 498	REV 499
REVISIONS	REV 500	REV 501
REVISIONS	REV 502	REV 503
REVISIONS	REV 504	REV 505
REVISIONS	REV 506	REV 507
REVISIONS	REV 508	REV 509
REVISIONS	REV 510	REV 511
REVISIONS	REV 512	REV 513
REVISIONS	REV 514	REV 515
REVISIONS	REV 516	REV 517
REVISIONS	REV 518	REV 519
REVISIONS	REV 520	REV 521
REVISIONS	REV 522	REV 523
REVISIONS	REV 524	REV 525
REVISIONS	REV 526	REV 527
REVISIONS	REV 528	REV 529
REVISIONS	REV 530	REV 531
REVISIONS	REV 532	REV 533
REVISIONS	REV 534	REV 535
REVISIONS	REV 536	REV 537
REVISIONS	REV 538	REV 539
REVISIONS	REV 540	REV 541
REVISIONS	REV 542	REV 543
REVISIONS	REV 544	REV 545
REVISIONS	REV 546	REV 547
REVISIONS	REV 548	REV 549
REVISIONS	REV 550	REV 551
REVISIONS	REV 552	REV 553
REVISIONS	REV 554	REV 555
REVISIONS	REV 556	REV 557
REVISIONS	REV 558	REV 559
REVISIONS	REV 560	REV 561
REVISIONS	REV 562	REV 563
REVISIONS	REV 564	REV 565
REVISIONS	REV 566	REV 567
REVISIONS	REV 568	REV 569
REVISIONS	REV 570	REV 571
REVISIONS	REV 572	REV 573
REVISIONS	REV 574	REV 575
REVISIONS	REV 576	REV 577
REVISIONS	REV 578	REV 579
REVISIONS	REV 580	REV 581
REVISIONS	REV 582	REV 583
REVISIONS	REV 584	REV 585
REVISIONS	REV 586	REV 587
REVISIONS	REV 588	REV 589
REVISIONS	REV 590	REV 591
REVISIONS	REV 592	REV 593
REVISIONS	REV 594	REV 595
REVISIONS	REV 596	REV 597
REVISIONS	REV 598	REV 599
REVISIONS	REV 600	REV 601
REVISIONS	REV 602	REV 603
REVISIONS	REV 604	REV 605
REVISIONS	REV 606	REV 607
REVISIONS	REV 608	REV 609
REVISIONS	REV 610	REV 611
REVISIONS	REV 612	REV 613
REVISIONS	REV 614	REV 615
REVISIONS	REV 616	REV 617
REVISIONS	REV 618	REV 619
REVISIONS	REV 620	REV 621
REVISIONS	REV 622	REV 623
REVISIONS	REV 624	REV 625
REVISIONS	REV 626	REV 627
REVISIONS	REV 628	REV 629
REVISIONS	REV 630	REV 631
REVISIONS	REV 632	REV 633
REVISIONS	REV 634	REV 635
REVISIONS	REV 636	REV 637
REVISIONS	REV 638	REV 639
REVISIONS	REV 640	REV 641
REVISIONS	REV 642	REV 643
REVISIONS	REV 644	REV 645
REVISIONS	REV 646	REV 647
REVISIONS	REV 648	REV 649
REVISIONS	REV 650	REV 651
REVISIONS	REV 652	REV 653
REVISIONS	REV 654	REV 655
REVISIONS	REV 656	REV 657
REVISIONS	REV 658	REV 659
REVISIONS	REV 660	REV 661
REVISIONS	REV 662	REV 663
REVISIONS	REV 664	REV 665
REVISIONS	REV 666	REV 667
REVISIONS	REV 668	REV 669
REVISIONS	REV 670	REV 671
REVISIONS	REV 672	REV 673
REVISIONS	REV 674	REV 675
REVISIONS	REV 676	REV 677
REVISIONS	REV 678	REV 679
REVISIONS	REV 680	REV 681
REVISIONS	REV 682	REV 683
REVISIONS	REV 684	REV 685
REVISIONS	REV 686	REV 687
REVISIONS	REV 688	REV 689
REVISIONS	REV 690	REV 691
REVISIONS	REV 692	REV 693
REVISIONS	REV 694	REV 695
REVISIONS	REV 696	REV 697
REVISIONS	REV 698	REV 699
REVISIONS	REV 700	REV 701
REVISIONS	REV 702	REV 703
REVISIONS	REV 704	REV 705
REVISIONS	REV 706	REV 707
REVISIONS	REV 708	REV 709
REVISIONS	REV 710	REV 711
REVISIONS	REV 712	REV 713
REVISIONS	REV 714	REV 715
REVISIONS	REV 716	REV 717
REVISIONS	REV 718	REV 719
REVISIONS	REV 720	REV 721
REVISIONS	REV 722	REV 723
REVISIONS	REV 724	REV 725
REVISIONS	REV 726	REV 727
REVISIONS	REV 728	REV 729
REVISIONS	REV 730	REV 731
REVISIONS	REV 732	REV 733
REVISIONS	REV 734	REV 735
REVISIONS	REV 736	REV 737
REVISIONS	REV 738	REV 739
REVISIONS	REV 740	REV 741
REVISIONS	REV 742	REV 743
REVISIONS	REV 744	REV 745
REVISIONS	REV 746	REV 747
REVISIONS	REV 748	REV 749
REVISIONS	REV 750	REV 751
REVISIONS	REV 752	REV 753
REVISIONS	REV 754	REV 755
REVISIONS	REV 756	REV 757
REVISIONS	REV 758	REV 759
REVISIONS	REV 760	REV 761
REVISIONS	REV 762	REV 763
REVISIONS	REV 764	REV 765
REVISIONS	REV 766	REV 767
REVISIONS	REV 768	REV 769
REVISIONS	REV 770	REV 771
REVISIONS	REV 772	REV 773
REVISIONS	REV 774	REV 775
REVISIONS	REV 776	REV 777
REVISIONS	REV 778	REV 779

APPENDIX E

REPORT
SA-TR20-2809

DISTRIBUTION

	<u>Copies</u>
✓ Chief of Ordnance Department of the Army Washington 25, D. C. ATTN: ORDTB (2) ORDIX (2) ORDTS (1)	} 5
✓ Commanding General Ordnance Weapons Command Rock Island, Illinois ATTN: ORDOW-TB (1) ORDOW-TX (1) ORDOW-FM (1)	3
✓ Commanding Officer Diamond Ordnance Fuze Laboratories Washington 25, D. C. ATTN: <u>Technical Reference Section</u> ORDTL 06.33	1
✓ Armed Services Technical Information Agency Arlington Hall Station Arlington 12, Virginia	10
✓ Commanding Officer Detroit Arsenal Center Line, Michigan ATTN: Tank Automotive Computer Laboratory	1
✓ Commanding General Frankford Arsenal Philadelphia, Pennsylvania ATTN: Pitman-Dunn Laboratory (1) Small Arms Division (1)	2
✓ Commanding Officer Picatinny Arsenal Dover, New Jersey	1

REPORT 2809
SA-TR20-~~2205~~

APPENDIX E

DISTRIBUTION - Continued

	<u>Copies</u>
✓ Commanding General Redstone Arsenal Huntsville, Alabama ATTN: ARGMA (1) ABMA (1)	2
✓ Commanding Officer Rock Island Arsenal Rock Island, Illinois ATTN: Laboratory	1
✓ Commanding Officer Watertown Arsenal Watertown, Massachusetts ATTN: OMRO (1) Laboratory (1)	2
✓ Commanding Officer Watervliet Arsenal Watervliet, New York	1
✓ Commanding General Aberdeen Proving Ground Aberdeen, Maryland ATTN: Technical Library, ORDBQ-LM, Bldg. 313 (2) DPS, Branch Library #3, Bldg. 400 (2) BRL, Computing Laboratory (2)	6
✓ Commanding Officer U. S. Army Ordnance Training Command Aberdeen Proving Ground, Maryland ATTN: ORDHB-CR-C	1
✓ Commandant U. S. Army Ordnance School Aberdeen Proving Ground, Maryland ATTN: USAOS Technical Library (1) Non-Resident Training Division (1)	2

APPENDIX E

REPORT
SA-TR20-2809

DISTRIBUTION - Continued

	<u>Copies</u>
✓ Commanding Officer Bureau of Naval Weapons Technical Liaison Office Aberdeen Proving Ground, Maryland ATTN: Navy Liaison Office, Bldg. 305	1
✓ Commanding Officer U. S. Army Ordnance Technical Intelligence Office Aberdeen Proving Ground, Maryland ATTN: ORDBG -OTI, Capt. Taylor	1
✓ Commanding General White Sands Proving Ground Las Cruces, New Mexico	2
✓ <u>U. S. Army Research Office (Durham)</u> Post Office Box CM Duke Station Durham, North Carolina	4
✓ Commanding General U. S. Army Ordnance Special Weapons Ammunition Command Dover, New Jersey	1
✓ Chief, Bureau of Naval Weapons Department of the Navy Washington 25, D. C. ATTN: RRMA, RRRE	1
✓ Director U. S. Naval Research Laboratory Washington 20, D. C. ATTN: Technical Information Officer	1
✓ Superintendent U. S. Naval Weapons Plant Washington 25, D. C. ATTN: S. Kent	1
✓ Commander (Code 5557) U. S. Naval Ordnance Test Station China Lake, California	1

REPORT
SA-TR20-2809

APPENDIX E

DISTRIBUTION - Continued

Copies

✓ National Aeronautics and Space Administration
George C. Marshall Space Flight Center
ATTN: Mr. W. R. Lucas M-S & M-M (1)
Mr. W. A. Wilson, M-F & AE-M (1)
Huntsville, Alabama

2